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Millimeter Wave Imaging and Evaluation of Surface-Breaking Cracks in Metal Structures with Surface Pitting and Corrosion

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Detection of surface-breaking discontinuities (cracks) in metallic surfaces has been a widely researched area using a number of well-established nondestructive testing (NDT) techniques. However, detection of such discontinuities when covered by paint or other dielectric coatings or in the presence of sever surface pitting and corrosion presents a significant challenge. Microwave and millimeter wave NDT techniques, specifically designed for surface-breaking crack detection and evaluation in metals, have shown great potential for overcoming some of these challenges. The ability of these waves to readily penetrate dielectric coatings and corrosion layers, in addition to the fact that reflection properties of a surface-breaking crack and pitting are markedly different, makes these methods very attractive for this purpose. These techniques have also been used to distinguish among surface-breaking cracks, scratches and pitting. Furthermore, these techniques utilize a diverse array of probes (i.e., open-ended coaxes, waveguides, microstrip patches, etc.), each of which offer certain advantages for a specific application. Finally, near-field measurements vs. high-resolution imaging approaches provide an important practical diversity that may not be possible with other NDT techniques. These techniques rely on the properties of surface current density on a metallic structure that interacts with a surface-breaking crack which presents a significant perturbation to the current density. A pitting on the other hand is more of a subtle change in the surface and presents a less significant perturbation to the current density. Hence, one may effectively use the reflected signal from a metallic structure that contains a surface-breaking crack to detect it even in the presence of sever corrosion pitting. This presentation illustrates the efficacy of wideband millimeter wave NDT for detecting narrow notches (0.006") with different lengths and depth, machined on a steel plate which was pitted and successively corroded in a salt-fog chamber creating corrosion pitting of different severity in each succession. Prior to each corrosion cycle, images of the plate were produced by scanning over a wide range of frequencies covering Ka-band (26.5-40 GHz) and V-band (50-75 GHz). Results of these measurements as well as discussions of the results will be presented.

References:

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